Small Business Innovation Research/Small Business Tech Transfer

Smallsat Swarm Sparse Aperture SAR for Recon and Surveillance (SSSASAfRaS), Phase I

Completed Technology Project (2018 - 2019)

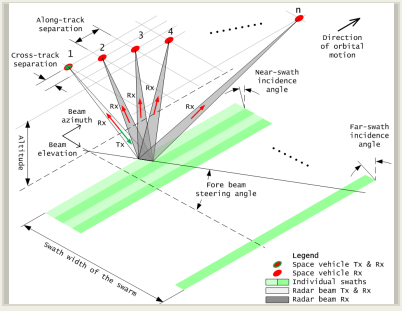
Project Introduction

The goal of the proposed Phase I work is to demonstrate the feasibility of the coordination and control of a low cardinality (n=12) swarm of smallsats that realizes a distributed Synthetic Aperture Radar (SAR) in low Earth orbit. Preliminary mission and spacecraft design work has shown that the swarm can support SAR imaging in the L-band (1.35 GHz) with a ground range resolution finer than 10 m with a revisit period of eight days. The spacecraft in the swarm are pre-programmed to rendezvous in a region, say a sphere or box of certain dimensions, centered at a specified set of (absolute) orbital elements. After deployment from the launcher each satellite maneuvers to bring itself into the rendezvous sphere while monitoring its surroundings with on-board means, such as the star tracker capable of taking still images while attempting to close inter-spacecraft radio communications (ISRC) links with its neighbors. Both (passive) optical or ISRC-based relative navigation are then used to determine the relative position and velocity vectors between spacecraft while they maneuver to aggregate the swarm in its nominal operations configuration. During swarm aggregation and nominal operations, algorithms developed in the framework of evolving systems ensure the stability of the swarm. Failure of one swarm member will also be simulated to analyze the swarm reconfiguration and recovery of nominal operations after reconfiguration. Formal proofs of feedback control system properties such as controllability-observability, stability, detectabililty, and robustness will be pursued to establish a solid theoretical foundation for the proposed algorithms. The Phase I feasibility demonstration will meet most of the technical objectives identified in the solicitation for the corresponding modes of swarm operations.

Anticipated Benefits

The evolving system algorithms proposed have a “common core” which can be applied to swarms of dynamic devices ranging from spacecraft to atmospheric and surface vehicles that cooperate to fulfill tasks beyond the capabilities of member. Swarm members can operate at a distance, without physical contact, such as the distributed SAR swarm proposed, or with physical contact such as in-orbit assembly of orbital solar power stations and commercial infrastructure.

Near-term applications of the algorithms are to autonomous road or off-road vehicles or ships. For example, the rendezvous between swarm members, of the distributed SAR mission, followed by swarm aggregation to acquire its configuration for nominal operations is quite similar to convoy formation and deployment for surface vehicles performing (re)supply operations for either defense or commercial use.



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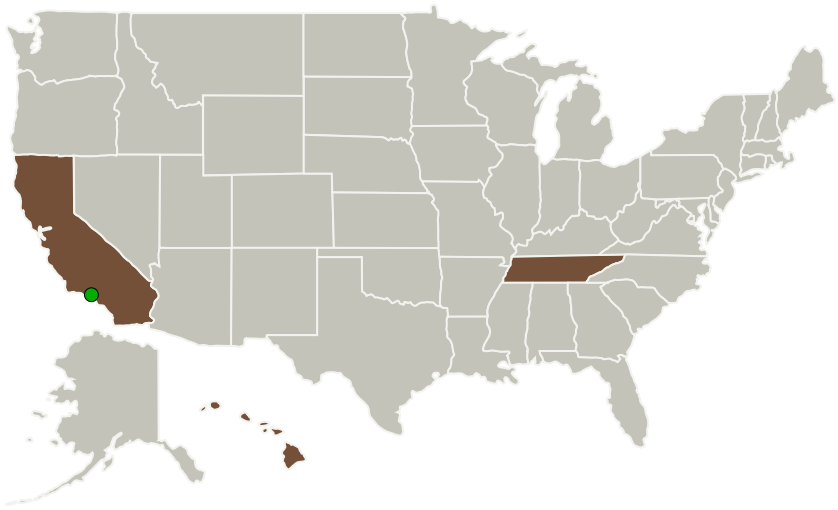
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
VisSidus Technologies, Inc.	Lead Organization	Industry	Daytona Beach, Florida
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California
The University of Tennessee-Knoxville(UT-K)	Supporting Organization	Academia	Knoxville, Tennessee

Primary U.S. Work Locations	
California	Hawaii
Tennessee	

Project Transitions

July 2018: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

VisSidus Technologies, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

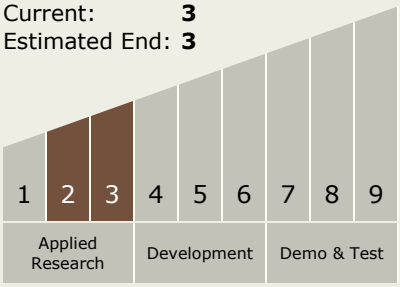
Carlos Torrez

Principal Investigator:

Bogdan Udrea

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



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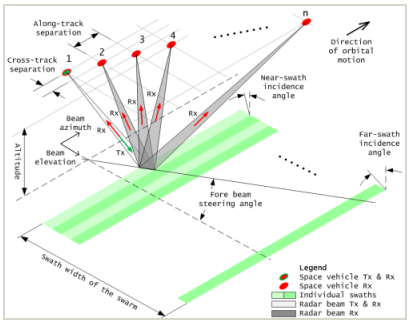
August 2019: Closed out

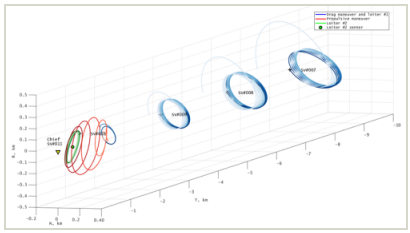
Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141299)*

Images



Briefing Chart Image
Smallsat Swarm Sparse Aperture SAR for Recon and Surveillance (SSSASAfRaS), Phase I *(https://techport.nasa.gov/image/132842)*



Final Summary Chart Image
Smallsat Swarm Sparse Aperture SAR for Recon and Surveillance (SSSASAfRaS), Phase I *(https://techport.nasa.gov/image/134899)*

Technology Areas

Primary:

- TX10 Autonomous Systems
  - TX10.2 Reasoning and Acting
    - TX10.2.7 Learning and Adapting

Target Destination

Earth